OPERATION AND SERVICE MANUAL

FOR

GMC MODELS 454A, 454AR

THERMOELECTRIC POWER METER

GENERAL MICROWAVE

CORPORATION

INSTRUMENT SHOP

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GENERAL MICROWAVE CORPORATION

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Farmingdale, New York 11735

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SECTION I - GENERAL

1.1 DESCRIPTION

The GMC Model 454A Thermoelectric Power Meter, together with appropriate models of the ( ) 420, ( ) 421 and ( ) 422 series of GMC tft Power Heads, is a highly accurate instrument designed to measure radio frequency power over an extremely wide range of power and frequency. The unit measures and indicates the average power absorbed by the tft Power Head in use, and will accept amplitude and frequency modulated, as well as CW, signals subject only to the maximum average and peak power ratings of the tft head.

The Model 454A is suitable for use in a wide variety of applications, including fixed stations, as well as laboratory bench set-ups. Since all tft Power Heads will operate with the Model 454A, a single instrument with different heads can be applied to a wide variety of measurement problems.

The Model 454A is also available in a 19 inch-wide rack-mountable version, Model 454AR. In addition both the Models 454A and 454AR can be furnished with the input connector at the rear when this option is requested by the customer.

1.2 PRIMARY POWER REQUIREMENTS

The Model 454A is normally shipped with connections for operation at 115V a-c, 60 cps. Versions of the Model 454A for operation at either 50 cps or 50 to 1000 cps are available on special order. Examine the rear chassis apron for the line frequency requirements of the unit in your possession.

To operate at 230V a-c, convert the power transformer connections in accordance with the following procedure:

A. Remove the jumpers between terminals 1-3 and 2-4.

B. Install a jumper between terminals 2 and 3.

C. Replace the fuse with a 1/4 amp size.

When using a 50-1000 cps unit, it should be noted that beat notes will arise between certain line frequencies and harmonics of the chopper frequency, producing erratic performance of the Model 454A. The forbidden frequency bands are: 61-63 cps, 82-106 cps, 182-192 cps, 278-283 cps, 365-382 cps, 556-566 cps, 744-753 cps, 931-937 cps.

1.3 tft POWER HEADS

The Model 454A requires a tft Power Head in order to form a complete power measuring system. A number of tft Power Heads are presently available. Their salient characteristics are listed in Table I.

1.4 SPECIFICATIONS

1.4.1 POWER RANGE: Twelve ranges with full-scale indications of 0.3, 1.0, 3.0, 10, 30, 100, and 300 microwatts and 1.0, 3.0, 10, 30, and 100 milliwatts. Corresponding dbm indications vary from -35 to +20 dbm.

1.4.2 FREQUENCY RANGE: Dependent only upon the tft Power Head in use.

1.4.3 ACCURACY: ±1% of full-scale indication.

1.4.4 NOISE AND DRIFT: Less than ±0.5% peak-to-peak of full scale on the lowest ranges (except for the high sensitivity position where it may rise to ±1% peak-to-peak) at constant ambient; correspondingly less on higher ranges.

1.4.5 TEMPERATURE COEFFICIENT: 0.1% per degree C, maximum.

1.4.6 RESPONSE TIME: Less than 1 second except for the lowest range where it is less than 1.5 seconds.

1.4.7 ZERO SET: Single electrical zeroing control carries over from range to range.

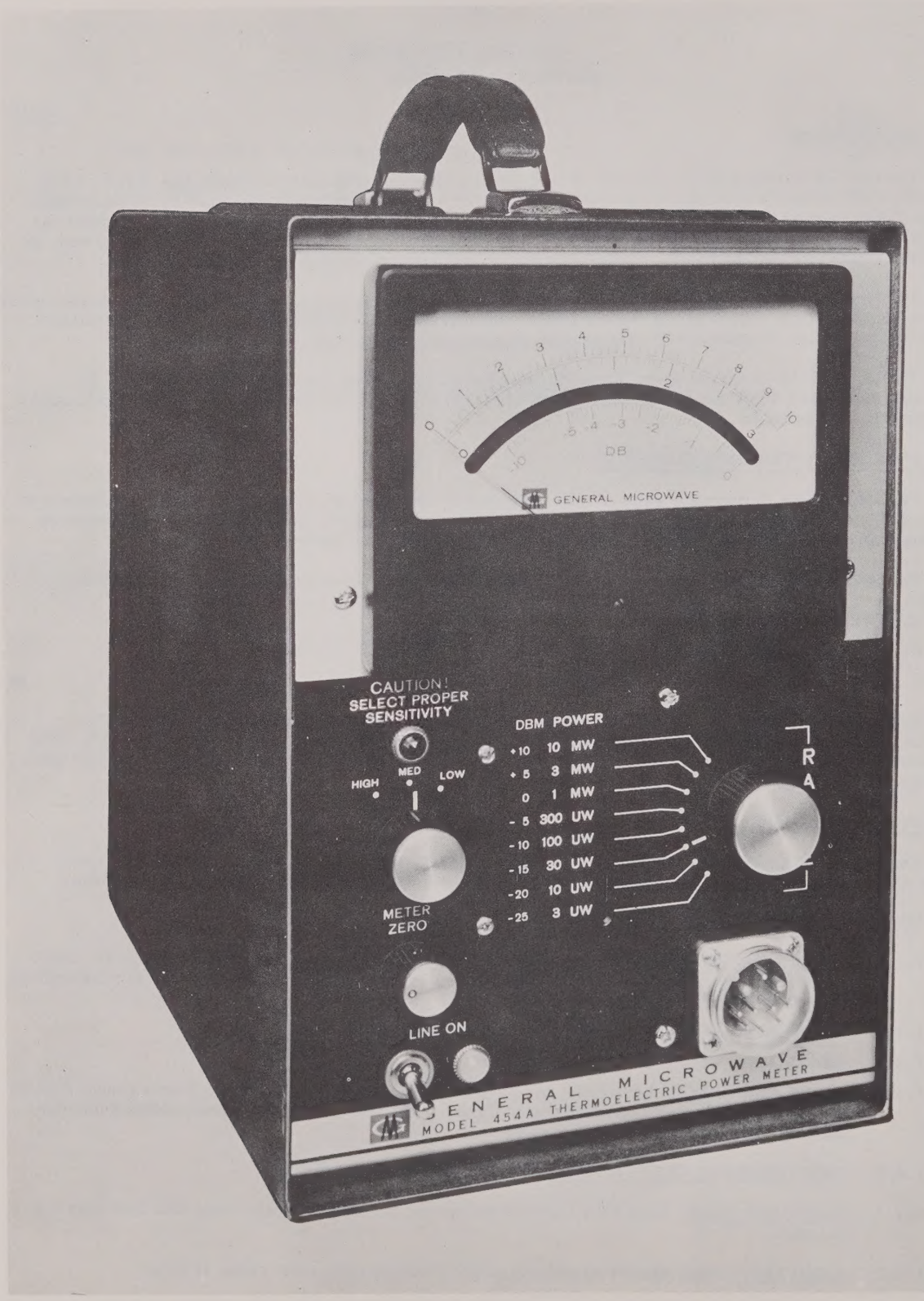


Figure 1. GMC Model 454A Thermoelectric Power Meter

1.4.8 RECORDER/VOLTMETER OUTPUT: Rear mounted phone jack permits operation of up to 1 ma recorder or use of external digital voltmeter for increased accuracy.

1.4.9 INPUT POWER: 115/230V a-c, ±10%, 60 cps. (50 cps and 50 to 1000 cps versions available on special order.) Approximately 30 watts.

1.4.10 DIMENSIONS: 454A: 7-1/2" W x 11-1/2" H x 14" D
454AR: 19" W x 7" H x 14" D

1.4.11 WEIGHT: 454A: 19 lbs
454AR: 17 lbs

1.4.12 ACCESSORIES AVAILABLE BUT NOT SUPPLIED:

1.4.12.1 Five-point Junction Box Model 963R
1.4.12.2 Voltmeter Adapter Cable Model W964

TABLE I

CHARACTERISTICS OF tft POWER HEADS

Model No.	Freq Range GC	Waveguide Size	Waveguide Type	Flange Type	Power Range
N420	0.002 - 12.4		Coax	Type N Male	3 μw to 10 mw
N421	0.002 - 12.4		Coax	Type N Male	30 μw to 100 mw
N422	0.002 - 12.4		Coax	Type N Male	0.3 μw to 1 mw
S420	2.6 - 3.95	3 x 1-1/2	RG-48/U	UG-53/U	3 μw to 10 mw
G420	3.95 - 5.85	2 x 1	RG-49/U	UG-194/U	3 μw to 10 mw
C420	5.3 - 8.2	1-1/2 x 3/4	RG-50/U	UG-344/U	3 μw to 10 mw
J420	7.05 - 10.0	1-1/4 x 5/8	RG-51/U	UG-51/U	3 μw to 10 mw
X420	8.2 - 12.4	1 x 1/2	RG-52/U	UG-39/U	3 μw to 10 mw
U420	12.4 - 18.0	0.702 x 0.391	RG-91/U	UG-419/U	3 μw to 10 mw
K420	18.0 - 26.5	0.500 x 0.250	RG-66/U	UG-595/U	3 μw to 10 mw
A420	26.5 - 40.0	0.360 x 0.220	RG-91/U	UG-599/U	3 μw to 10 mw

SECTION II - OPERATING INSTRUCTIONS

2.1 OPERATING CONTROLS

All controls necessary for the operation of the Model 454A are located on the front panel. See figure 1 for their locations.

2.1.1 RANGE: The RANGE switch permits selection of the desired operating power range. The POWER and DBM markings are full-scale values.

2.1.2 SENSITIVITY: The SENSITIVITY selector is used to set the instrument in accordance with the sensitivity rating of the tft Power Head in use.

2.1.3 METER ZERO: The METER ZERO potentiometer is used to electrically zero the instrument.

2.1.4 LINE: The LINE switch applies primary power to the instrument.

2.2 OPERATING PROCEDURE

2.2.1 INTRODUCTION - There are no special precautions to be observed in using the Model 454A and tft Power Heads other than the normal good practice associated with accurate measurement procedures and the use of microwave components. In these respects, it is suggested that a warm-up period of about 10 minutes be allowed before using the equipment to permit circuit stabilization. The flange or connector of the tft Power Head should be handled with care to avoid scratching or marring the surfaces and connecting parts and should be covered with a protective cap when not in use to prevent accumulation of dirt and chips that can seriously affect performance. Finally, the power ratings of the tft Power Head should never be exceeded since permanent damage to the tft element may result. Although the power ratings are conservatively applied, that margin of safety should not be deliberately narrowed.

2.2.2 Turn the unit on by means of the LINE toggle switch.

2.2.3 Connect the tft Power Head to the front panel connector.

2.2.4 Set the SENSITIVITY selector to the correct position for the tft head in use. An incorrect setting of this control will cause the red pilot lamp directly above the switch to light. When the lamp is extinguished, the switch is in the correct position.

2.2.5 For best results, allow a 10-minute warmup before proceeding further.

2.2.6 Set the RANGE switch to the lowest position and adjust the meter reading to zero with the METER ZERO control. This control consists of a two-section potentiometer with built-in backlash of about 30° between the fine and coarse shafts. The limits of the fine control can be felt when the additional loading of the coarse section of the potentiometer is applied.

2.2.7 Set the RANGE switch to desired power range. (If the power to be measured is not approximately known, set the RANGE switch to the highest position and, after application of r-f power, reduce the setting as necessary.)

2.2.8 Connect the tft Power Head to the source of r-f power under test and read the power on the meter.

2.2.9 If it is desired to use a recorder to obtain a plot of power output versus time, or to connect a digital voltmeter to the amplifier output for increased accuracy, the rear-mounted phono jack should be employed. The Model 454A will deliver up to 1 ma d-c current or up to 0.2 volt open circuit for input signals corresponding to full scale deflection of the panel meter. A standard 1/4 inch diameter phone plug is required for this jack.

2.3 SPECIAL APPLICATION OF THE MODEL 454A TO D-C VOLTAGE MEASUREMENTS

The Model 454A is a high quality, sensitive d-c microvoltmeter which can be employed for null detection or d-c voltage measurement purposes. The nominal full-scale sensitivity of the instrument is 1.43 microvolts on the lowest range. Each step of the RANGE switch increases the full-scale voltage rating by 10 db (not the 5 db shown on the panel, which is a result of the square-law characteristic of the tft heads) and thus the 1-3-10 progression of the power scales is preserved when measuring voltage. By employing a special voltmeter cable,

Model W964, available as an accessory for the Model 454A, the unit will read directly in voltage starting at 1.0 microvolts on the lowest range and going up to 10 millivolts on the highest range.

Because of the low levels involved, extreme care must be exercised in measuring voltage to avoid generating spurious thermal emf's. Soldered connections, except when made with special low-thermal emf solder, and junctions of dissimilar metals, should be avoided. Mechanically bonded copper connections with large thermal mass are best.

Since the Model 454A panel meter is not a center-zeroed meter and does not employ a floating input, d-c voltages of only positive polarity can be measured. It is possible to electrically zero the meter at mid-scale on the lowest two ranges. This is particularly useful for null measurement work.

2.4 MULTI-POINT TESTING WITH THE MODEL 454A

Because the tft Power Heads are r-f power to d-c voltage transducers, it is possible to successively connect a number of different heads to a given Model 454A, thereby measuring power at different points in an r-f network, without readjustment of the Model 454A. Because the tft heads retain their matched characteristics even when not connected to the Model 454A, there is no danger of upsetting the network characteristics under these conditions.

To facilitate the use of a number of heads, a five-input junction box, Model 963R, is available from General Microwave Corporation. Any number of tft heads, from one up to five, can be employed with this unit. By cascading junction box units, still larger numbers of tft heads can be employed. Switching from unit to unit is performed by a front panel mounted, low noise rotary switch.

SECTION III - THEORY OF OPERATION

3.1 GENERAL CIRCUIT DESCRIPTION

The Model 454A is basically a d-c amplifier with the attributes of very low noise, high gain and high gain stability, with a self-contained meter to indicate its output signal. Because of the extremely low d-c signals involved (approximately 1.5 microvolts full-scale on the most sensitive range), a chopper-carrier system is employed to avoid drift orders of magnitude greater than this, a characteristic of even the best d-c amplifier.

Figure 2 is a block diagram of the overall unit. Figure 3 is a schematic diagram of the overall unit. The input signal is introduced directly to the chopper and the chopper output stepped up by the input transformer to the grid of the low noise amplifier, V1. This a-c signal is amplified by V1 and by V2 and then filtered by a bandpass filter centered at the chopper frequency to reduce noise, hum and other spurious signals. The filter output is coupled to V3, which provides additional gain and phase splitting action to drive the demodulator. The demodulator, which is synchronous with the input chopper, recovers the d-c signal at a greatly amplified level.

The output of the demodulator is then fed to a series of transistor d-c amplifiers and an emitter follower, all of which, by virtue of the feedback capacitor shown, form an operational integrator. These circuits serve to provide further signal gain as well as to reduce the amplifier bandwidth to the degree required consistent with response time and noise level. The output of the integrator drives the meter circuit as well as the recorder output, and is also fed back to the input via the range switch network. This feedback path provides a high degree of degeneration and thus gain stability, and at the same time offers a means of accurate control of the overall amplifier gain.

Because the transducer sensitivity of each tft head is different, the Model 454A gain must be varied with each head employed. This is accomplished by the tft calibration resistor, shown dotted in figure 2, which is located in the tft head. This resistor, which affects the meter sensitivity, is appropriately adjusted as part of the calibration procedure for each tft head, and thus permits each 454A to be used with any tft head without adjustment.

The presence of spurious d-c signals at the input to the amplifier must be anticipated due to thermal emf's as well as any slight unbalance that may be present in the tft head. To correct for these offset signals, a small adjustable d-c voltage is introduced at the input. This voltage is derived from the positive and negative power supplies and is controlled by the ZERO SET potentiometer.

Two regulated power supplies are included in the Model 454A, one designed to produce a positive 200 volt output and the other, a negative 10 volt output.

3.2 INPUT CIRCUIT

The input voltage is applied between ground and the center-tap of the input transformer primary (T1). The feedback signal, developed across resistor R56, is applied to the moving arm of the chopper (G1A). Thus, the difference voltage between the input and feedback signals is alternately applied to each half of the transformer primary. The magnitude of the feedback signal and, therefore, the amplifier gain, is determined by the ratio of the range switch resistors, R1 through R8, and R56. The full-wave a-c signal produced in the transformer primary is stepped up by a 16 to 1 factor to the grid of V1, a type 7025 low noise triode.

To eliminate thermal emf's in the input circuit, copper leads are employed throughout. All connections are either clamped or soldered with low thermal cadmium-tin solder. The chopper and input transformer employ copper leads and the transformer is carefully shielded to minimize hum pickup. The input connector employs copper pins for the signal lines.

The mechanical chopper normally supplied with the Model 454A is driven by a 6.3 volt, 60 cps signal and chops at 120 cps. For 50 cps line signals, a 50 cps unit is supplied that chops at 100 cps. Where operation over a range of input frequencies from 50 to 1000 cps is required, a 94 cps chopper is supplied along with a d-c to 94 cps transistorized inverter. The operating frequency of the bandpass filter found in the a-c amplifier is accordingly adjusted to operate at 120, 100 and 94 cps, respectively.

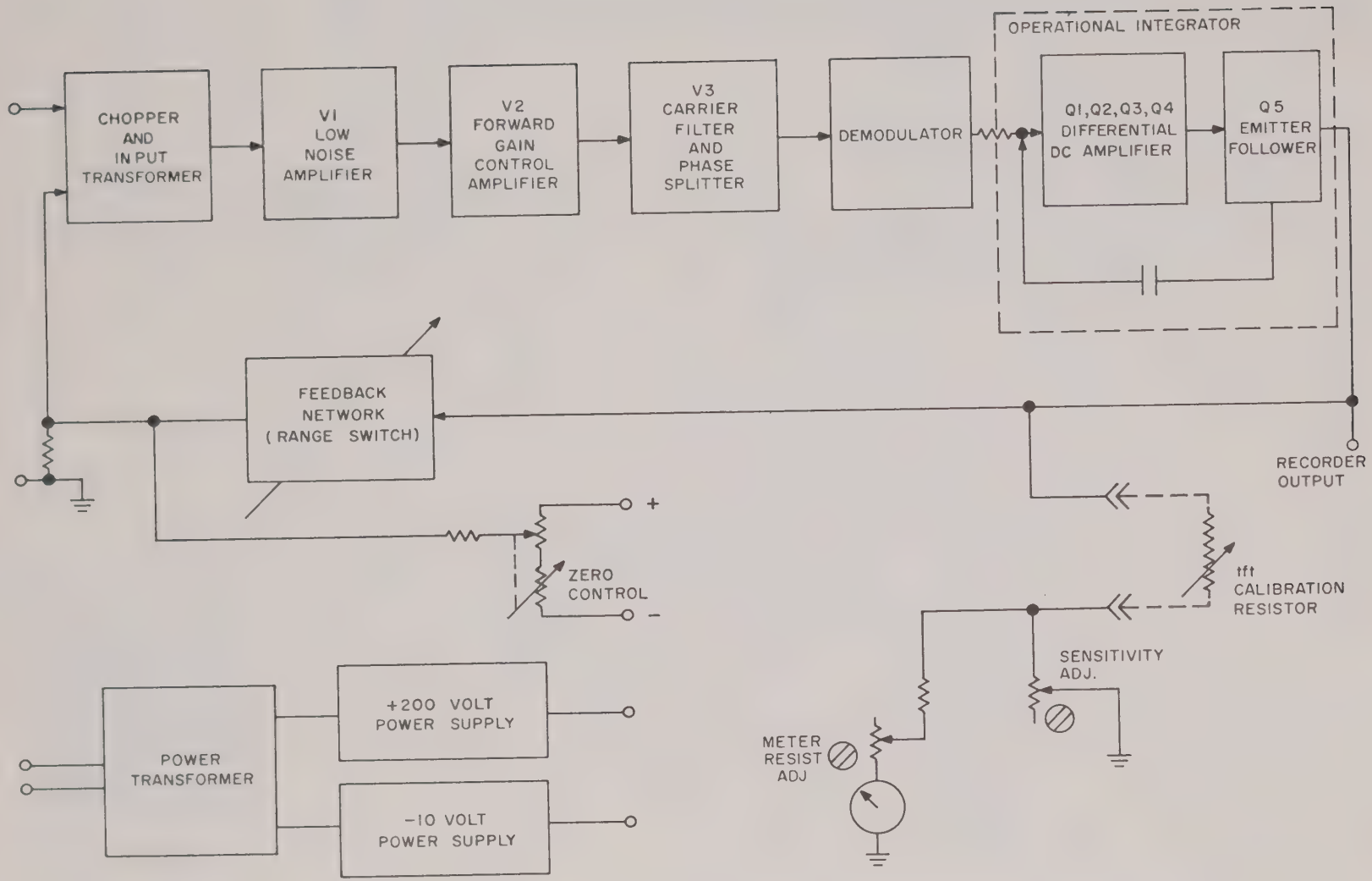
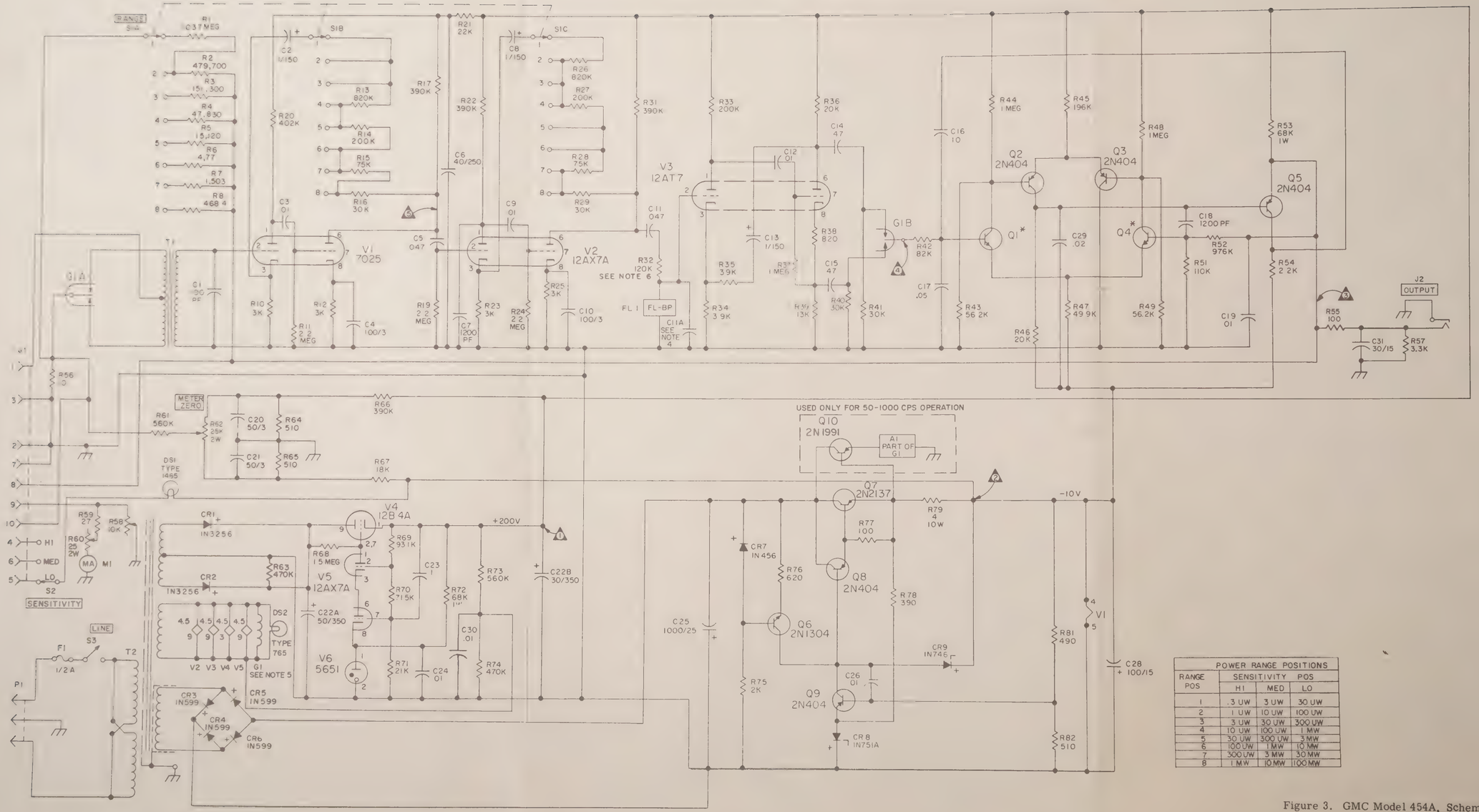


Figure 2. GMC Model 454A, Block Diagram



POWER RANGE POSITIONS			
RANGE POS	SENSITIVITY POS		
	HI	MED	LO
1	.3 UW	3 UW	30 UW
2	1 UW	10 UW	100 UW
3	3 UW	30 UW	300 UW
4	10 UW	100 UW	1 MW
5	30 UW	300 UW	3 MW
6	100 UW	1 MW	10 MW
7	300 UW	3 MW	30 MW
8	1 MW	10 MW	100 MW

NOTES:

1-All values, unless otherwise specified are:
Resistance in ohms
Resistor Wattage 1/2W
Capacitance in Microfarads

2-Transistors Marked * are matched pairs per GMC DWG 3011

3-Test point voltages and waveforms

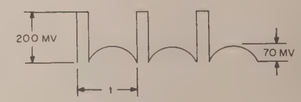
(1) Voltage should be 200 ±10VDC. Ripple should be less than 25 mv peak-to-peak.

(2) Voltage should be -10 ±0.6VDC. Ripple should be less than 5 mv peak-to-peak.

To measure the voltages at the remaining test points, first connect a 1ft Power Head or test jig to the unit, set the SENSITIVITY selector to the proper position and zero the instrument on the most sensitive scale (Range Pos. 1).

(3) With the RANGE selector in the most sensitive position, the d-c voltage at this point should be adjustable between 0 and 0.206 volts by varying the ZERO control. The ripple voltage should be less than 5 mv peak-to-peak.

(4) With the RANGE selector in the least sensitive position (Range Pos. 8), the waveform should appear approximately as shown below:



The time duration (t) should be as follows:

For units designed for 60 cps operation:
t = 4 m sec.

For units designed for 50 cps operation:
t = 4.8 m sec.

For units designed for 50-1000 cps operation:
t = 5.1 m sec.

As the RANGE selector is varied toward the most sensitive scale, noise and quadrature signal will begin to appear and eventually exceed the above waveform. On the most sensitive scale, the voltage will be about 0.8 volts peak-to-peak.

(5) With the RANGE selector in the least sensitive position, a 3 mv peak-to-peak square wave should appear at this point. There should be no evidence of amplifier overloading. The frequency of this square wave should be as follows:

For units designed for 60 cps operation:
f = 120 cps.

For units designed for 50 cps operation:
f = 100 cps.

For units designed for 50-1000 cps operation:
f = 94 cps.

As the RANGE selector is varied toward the most sensitive scale, the amplitude of the waveform should decrease until ripple and noise predominates.

4-Used only for 50 cps operation

5-Not used for 50-1000 cps operation ref. des. not assigned: R9, R18, R30, R50, R55, R57, R60

6-82K for 50 cps operation; 62K for 50-100 cps operation , 120K for 60cps operation

Figure 3. GMC Model 454A, Schematic Diagram

3.3 A-C AMPLIFIER

The a-c amplifier consists of five stages followed by a phase splitter and demodulator. The first two stages employ the two halves of V1, a type 7025 low noise twin triode. Local feedback from the plate of the second stage to the cathode of the input stage is varied by S1B and resistors R13 to R16 to minimize non-linearities in the overall amplifier system.

The third and fourth amplifiers employ a 12AX7A twin triode, V2, with local feedback controlled by S1C. The output of V2 is filtered by the action of R32 and the bandpass filter FL1.

The fifth amplifier stage and the phase splitter employ a 12AT7 twin triode (V3) with fixed local feedback provided via R35. The push-pull output is coupled to the fixed contacts of the demodulator G1B, which is synchronously driven with the chopper G1A.

3.4 D-C AMPLIFIER

The d-c output from the demodulator is coupled to the base of transistor Q1 which, together with Q4, forms a differential amplifier. These transistors are matched pairs to minimize drift with temperature. This differential amplifier couples to a second differential amplifier consisting of transistors Q2 and Q3 and the amplified output from the collector of Q2 is coupled to emitter follower Q5.

The emitter follower output drives the recorder output jack and provides the feedback signal around the entire amplifier chain via the range switch resistors. In addition, the collector of Q5 is capacitively coupled to the base of Q1 by C16, thus creating an a-c operational amplifier with a very small bandwidth to eliminate noise and modulation components present at the output of demodulator G1B.

3.5 tft POWER HEAD CALIBRATION AND INTERLOCK CIRCUITS

The absolute sensitivity of the Model 454A is factory adjusted by means of internal potentiometers R58 and R59 with a standard resistor connected between terminals 8 and 9 of J1. When a tft head is connected to the instrument, a potentiometer, located on the head, is connected to the same terminals. This potentiometer controls the Model 454A sensitivity and thus compensates for variations in the absolute sensitivity of different tft heads. When the tft element is replaced, this potentiometer is accordingly readjusted.

To alert the operator to the nominal sensitivity rating of the tft head in use, a panel light, DS1, and interlock circuit is provided. Of pins 4, 5 and 6 of J1, the two corresponding to the incorrect sensitivities are returned to ground in the tft Power Head connector. Thus, the light will be turned on when switch S2 is in the incorrect position.

3.6 POWER SUPPLIES

Two regulated power supplies are provided in the Model 454A. One, consisting of rectifiers CR1 and CR2, control amplifier V4, d-c amplifier V5 and voltage reference V6, provides a 200V output. The second uses a bridge rectifier, CR3 to CR6, a transistor regulator consisting of Q6, Q7, Q8 and Q9, and a Zener reference CR8. The output is nominally -10 volts.

SECTION IV - MAINTENANCE AND CALIBRATION PROCEDURE

4.1 GENERAL PARTS AND SERVICE INFORMATION

Standard, readily available components are used in the manufacture of GMC instruments whenever possible. Such parts can usually be obtained from a local parts jobber. Special parts are available from the GMC factory.

When ordering parts from the factory, please specify instrument model and serial number plus the component description and part number appearing in the Table of Replaceable Parts.

4.2 CABINET REMOVAL

4.2.1 Remove the two screws at the rear of the cabinet.

4.2.2 Push the chassis forward from the rear cabinet opening until the panel clears the cabinet. Then pull the unit out of the cabinet.

4.3 EQUIPMENT REQUIRED FOR TEST AND CALIBRATION

The equipment listed below, or any suitable equivalents, will be needed to test and calibrate the Model 454A.

A. Variable Autotransformer, Superior Electric Type 116.

B. Oscilloscope, Tektronix, Model 503.

C. 0-150 volt A-C Voltmeter, General Electric, Model AO-91.

D. D-C Voltmeter, John Fluke, Model 825A.

E. Calibration Test Jig

F. D-C Power Supply, Power Designs Model 4005.

G. Multimeter, Simpson Model 260.

NOTE

Because of the very low d-c voltages involved, calibration of the Model 454A must be conducted with special care. All connections to the input must be made with copper leads only and all solder connections in the input circuit must be made with cadmium-tin solder using a soldering iron which has been employed only with that type of solder.

To facilitate the calibration procedure, GMC recommends the construction of a test jig shown in fig. 4.

4.4 WARM-UP

4.4.1 Before applying power to the Model 454A, make continuity tests to insure that neither side of the line cord is connected to the chassis, and mechanically zero the meter if necessary.

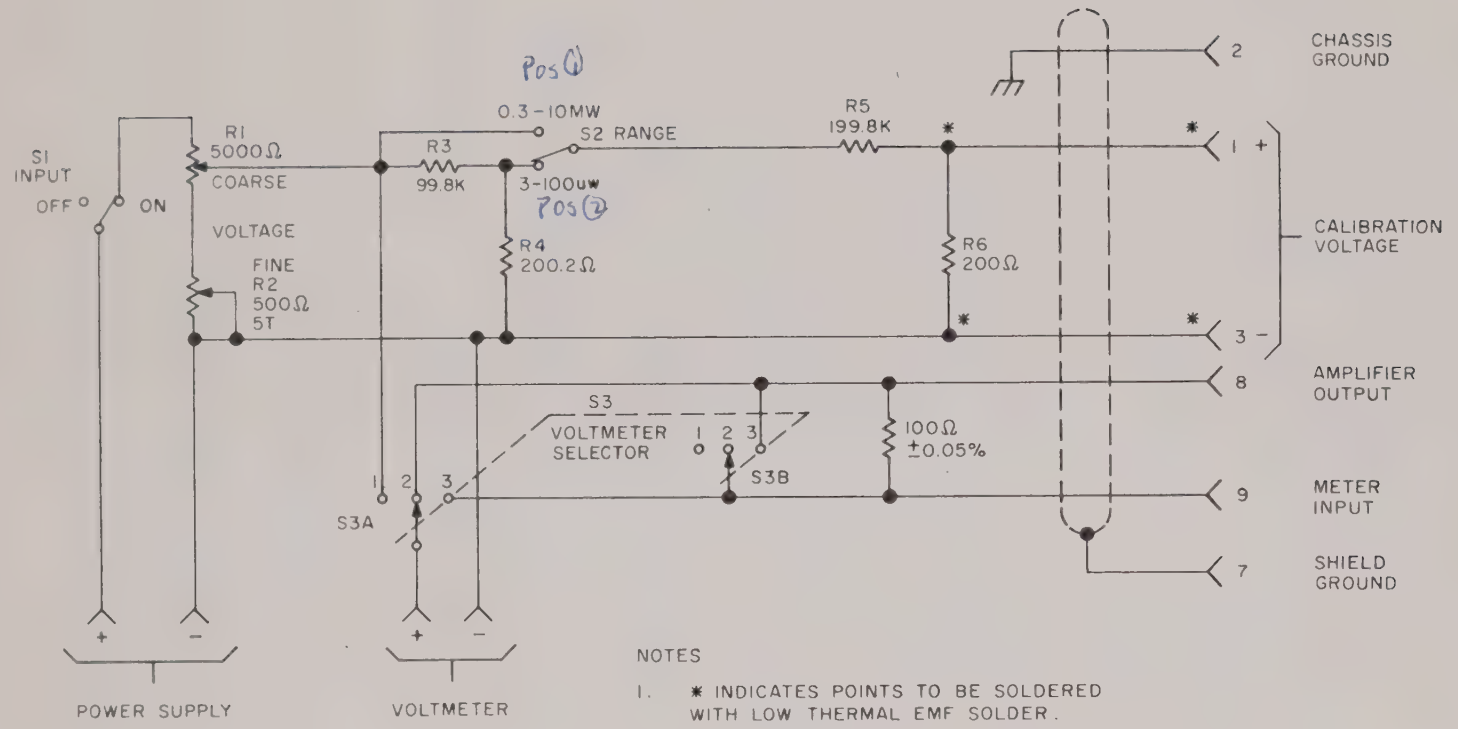
4.4.2 Connect the 454A to the variable autotransformer and set the line voltage to 115V RMS.

4.4.3 Turn the power switch to ON. Allow a 10-minute warmup period before continuing further tests.

4.5 POWER SUPPLY TEST

4.5.1 200 Volt D-C Test

4.5.1.1 Connect the D-C VTVM across C22B (30 μf, 350V). The voltmeter should read 200 ±10V d-c.



NOTES

1. * INDICATES POINTS TO BE SOLDERED WITH LOW THERMAL EMF SOLDER.
2. R6 TO BE WOUND OF EVANOHM WIRE WITH ENAMELED COPPER LEADS. ALL INTERNAL CONNECTIONS TO BE MADE WITH LOW THERMAL EMF SOLDER
3. UNLESS OTHERWISE NOTED, ALL FIXED RESISTORS ARE ±0.025%
4. CONNECTOR IS CANNON SK-13606-2 PINS 1 & 3 ARE SILVER PLATED COPPER

Figure 4. Calibration Test Jig, Schematic Diagram

4.5.1.2 Vary the line voltage between 103 and 127V. The variation should be less than ±1%.

4.5.1.3 Connect the oscilloscope across the voltmeter terminals and measure the power supply ripple. This should be less than 25 mv peak-to-peak.

4.5.2 -10V D-C Power Supply Test

4.5.2.1 Set the line voltage to 115V. Connect the d-c VTVM across C28 (100 μf, 15V D-C). The voltmeter should read 10 ±0.5V D-C.

4.5.2.2 Vary the line voltage between 103 and 127V. The variation should be less than ±1%.

4.5.2.3 Connect the oscilloscope across the voltmeter terminals and measure the power supply ripple. This should be less than 5 mv peak-to-peak.

4.6 VOLTMETER TEST AND CALIBRATION

Set the line voltage to 115V. Set the 454A controls as follows:

A. Sensitivity selector: MEDIUM.

B. R58 to the extreme CW position.

C. Range Selector: 3μw.

4.6.1 Connect the test jig to the unit with the test jig controls set as follows:

A. Range: 0.3-10 mw.

B. Input: OFF.

4.6.2 Connect the oscilloscope to the recorder output jack. By varying the zero control on the 454A, set the meter to mid-scale and observe the output ripple on the oscilloscope.

$$\text{RIPPLE} \leq \frac{120 \times 5 \text{ mv}}{\text{Chopper Freq.}}$$

4.6.3 Observe the drift and noise on the 454A meter. It should be less than 1% of full scale peak-to-peak.

4.6.4 Adjust the 454A zero control for a zero meter reading. Vary the 454A range selector from 3 μw to 10 mw and observe that the meter reads zero at every range position. Leave the range selector in the 10 mw position.

4.6.5 Connect the power supply and d-c VTVM to the appropriate terminals of the test jig. Set the VOLTMETER selector to POSITION 3 and the INPUT switch to ON. Adjust the test jig VOLTAGE controls and the power supply for a reading of exactly 0.1030 volts on the voltmeter. Adjust R60 for a full scale meter reading on the 0-10 scale.

4.6.6 Set the VOLTMETER selector to POSITION 2. Adjust the test jig voltage controls and the power supply for a reading of exactly 0.20600 volts on the voltmeter. Adjust R58 for a full scale meter reading on the 0-10 scale.

4.7 RESPONSE TIME

4.7.1 Set the test jig range switch to the 3-100 μw position and the 454A RANGE selector to 3 μw. Set the INPUT switch to ON. Vary the power supply and test jig voltage controls to obtain a full scale reading on the 454A meter.

4.7.2 Connect the oscilloscope to the recorder output jack. Set the oscilloscope vertical sensitivity control to 0.1V/CM, the sweep rate to 0.5 sec/cm, and input switch to d-c. By varying the position control, set the sweep to any convenient line on the graticule.

4.7.3 Set the INPUT switch on the test jig to OFF and after the 454A meter has returned to zero, reset the INPUT switch to ON and observe the response time (0 to 99% of full scale of the 454A on the meter). This should be 1.0 ±0.5 seconds.

4.8 RANGE-TO-RANGE ACCURACY

4.8.1 Set the test jig VOLTMETER selector to POSITION 1. Set the 454A and test jig range controls as listed in Table II. At each range setting, re-check zero, then adjust the power supply and test jig voltage controls for a full scale indication on the 454A meter. Full scale is 10 for all ranges measured. The voltage read on the voltmeter should fall within the specified limits.

TABLE II
RANGE-TO-RANGE ACCURACY READINGS

454A Range	Test Jig Range	Nominal Voltage	Limits	
			Low	High
10 mw	0.3-10 mw	4.312	4.290	4.334
3 mw	0.3-10 mw	1.363	1.356	1.370
1 mw	0.3-10 mw	0.4312	0.4290	0.4334
0.3 mw	3-10 mw	0.1363	0.1356	0.1370
100 μw	3-100 μw	21.56	21.45	21.67
30 μw	3-100 μw	6.817	6.783	6.851
10 μw	3-100 μw	2.156	2.145	2.167
3 μw	3-100 μw	0.6817	0.6783	0.6851

4.9 VOLTMETER STABILITY

4.9.1 Set the test jig RANGE switch to the 3-100 μw position. Set the 454A RANGE switch to 3 μw. Set the line voltage to 115V.

4.9.2 Adjust the power supply and test set voltage controls for a half scale meter deflection of the 0-10 scale.

4.9.3 Set the line voltage to 103V RMS. The 454A meter should not change by more than 0.5% of full scale.

4.9.4 Repeat 4.9.3 setting the line voltage to 127V.

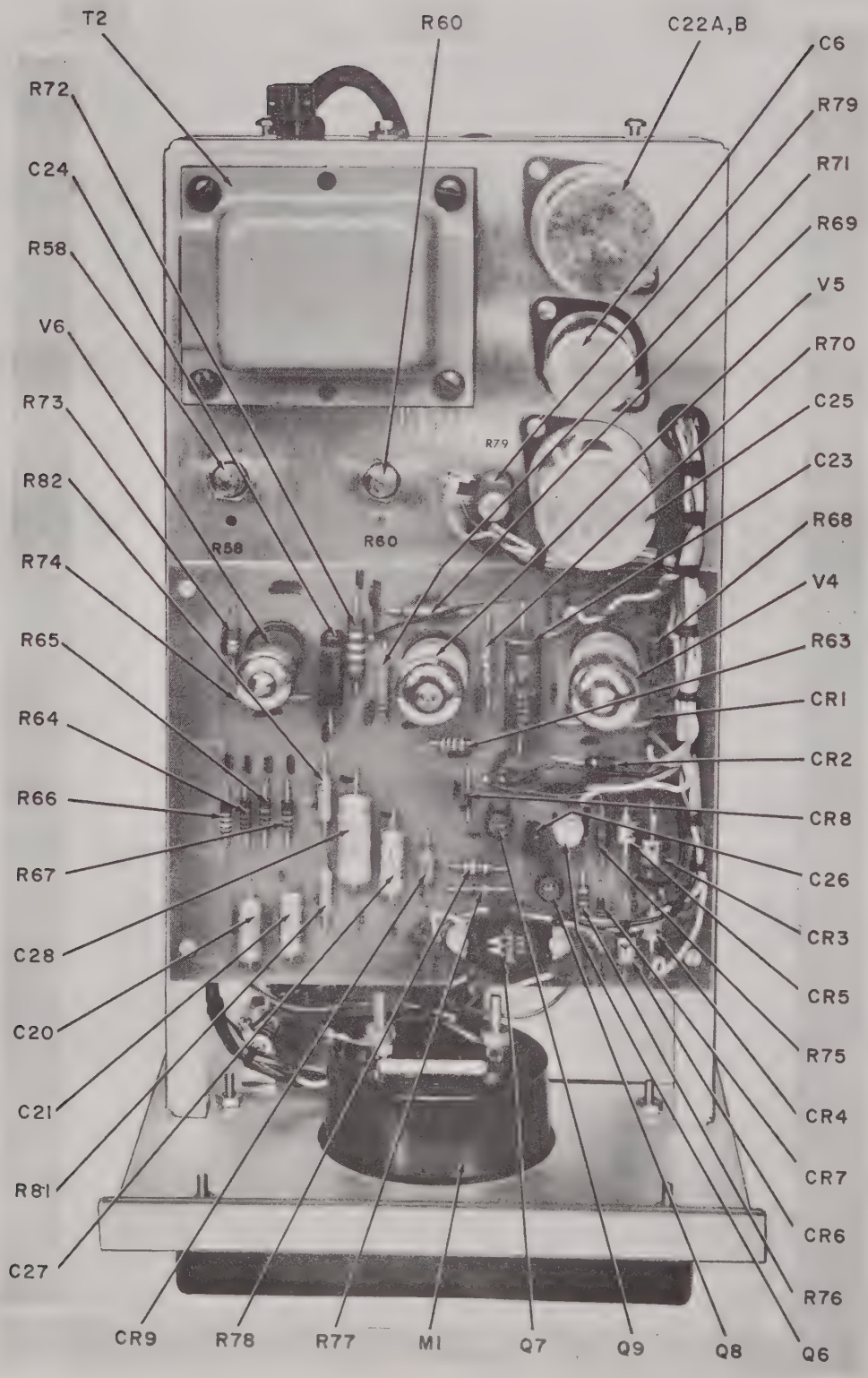


Figure 5. Model 454A Thermoelectric Power Meter, Top View

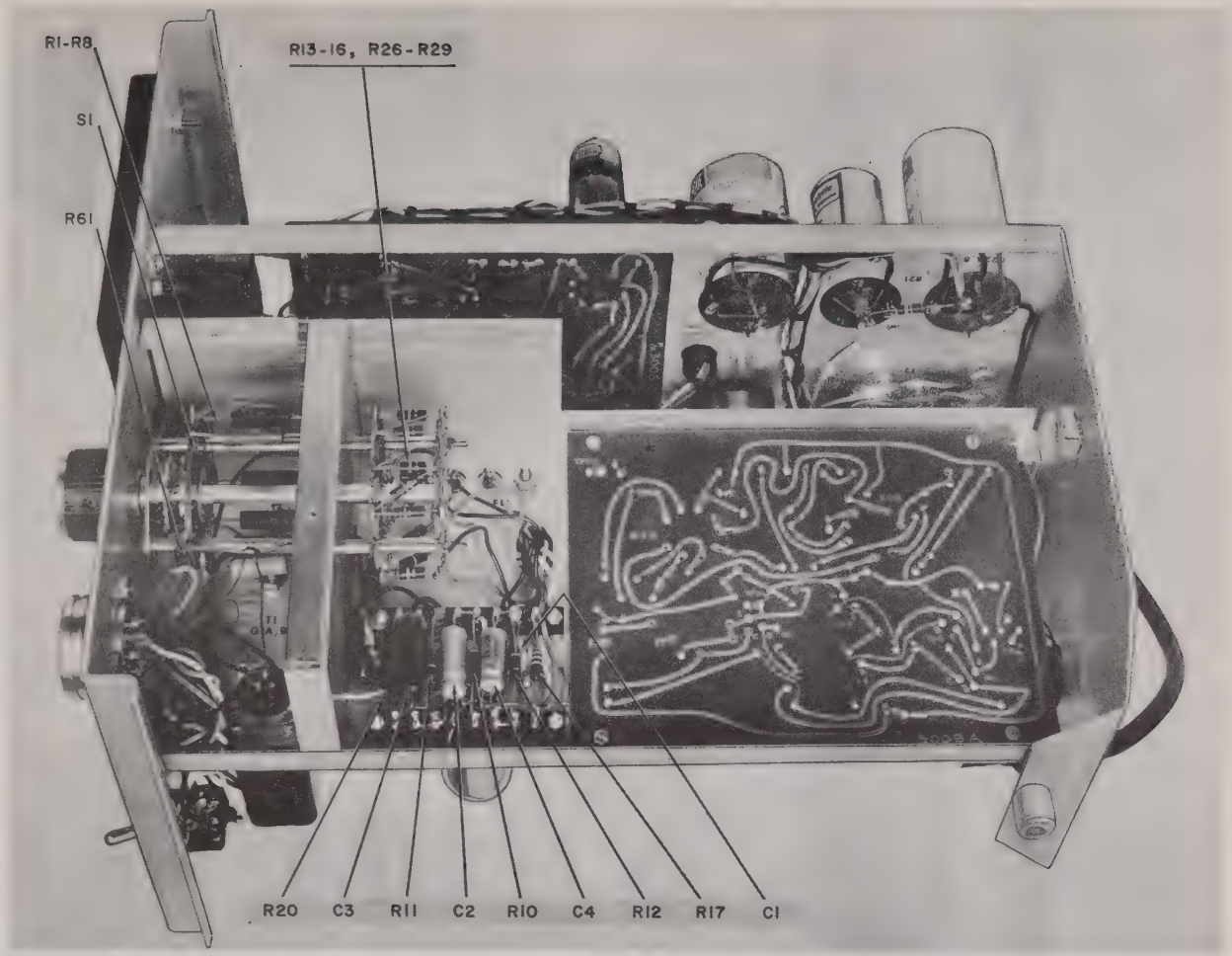


Figure 6. Model 454A Thermoelectric Power Meter, Right Side View

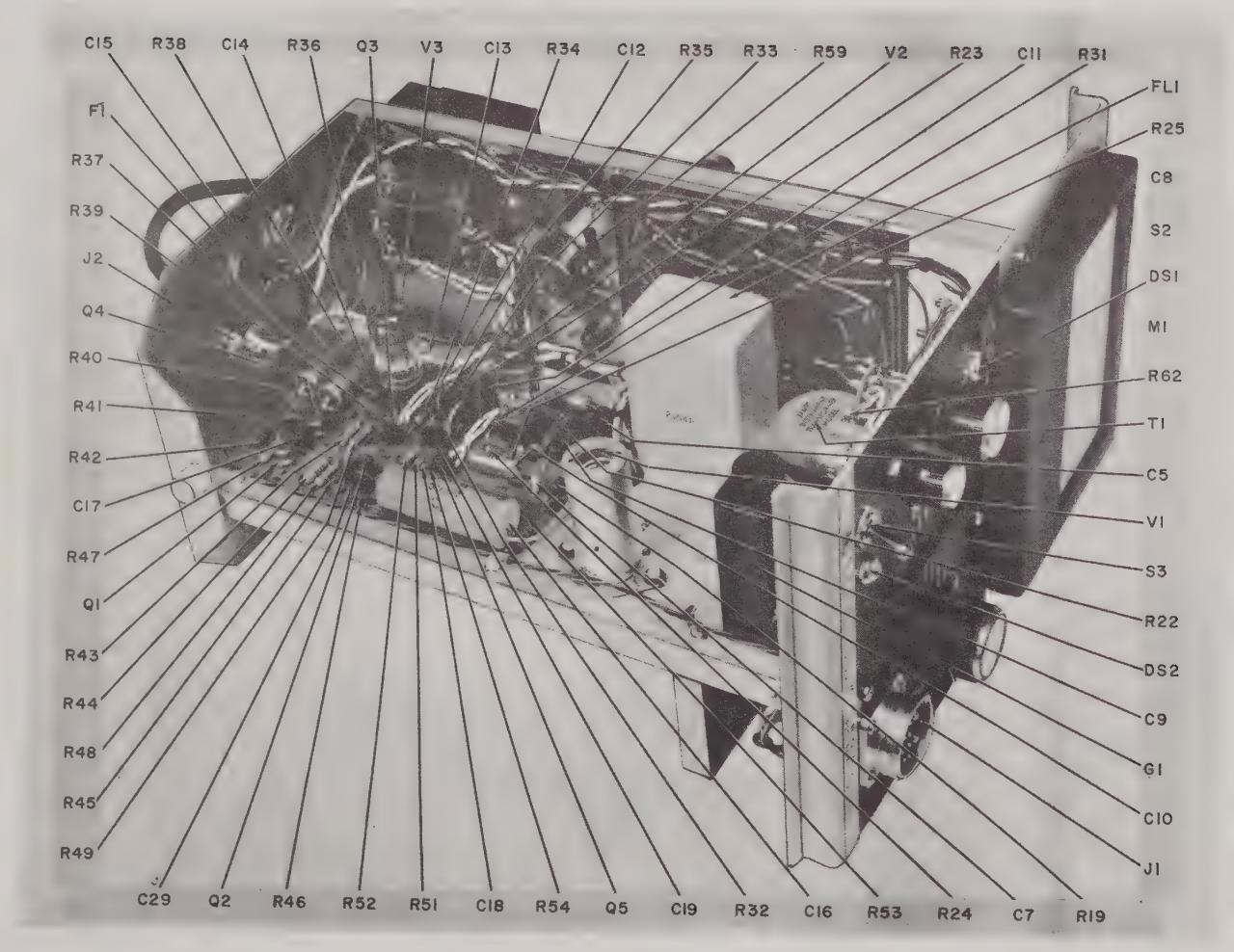


Figure 7. Model 454A Thermoelectric Power Meter, Left Side View

SECTION V - REPLACEABLE PARTS

5.1 INTRODUCTION

This section contains information for ordering replacement parts for the Model 454A Thern. oelectric Power Meter.

Table III Replaceable Parts lists replaceable parts in alpha-numerical order of their reference designations. Detailed information on a part used more than once in the instrument is listed opposite the first reference designator applying to the part. Other reference designators applying to the same part refer to the initial designator. Miscellaneous parts are included at the end of the list. Detailed information includes the following:

A. Reference designator.

B. Full description of the part.

C. Total number used in the instrument.

D. Manufacturer's code; (See Table IV, List of Manufacturer's Codes)

E. General Microwave part number.

5.2 ORDERING INFORMATION

To order a replacement part, address order or inquiry to

General Microwave Corporation
155 Marine Street
Farmingdale, N. Y.

Specify the following information for each part:

A. Model and complete serial number of instrument.

B. General Microwave part number if assigned.

C. Circuit reference designator.

D. Description.

To order a part not listed in the table, give a complete description of the part and include its function and location.

TABLE III

REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION	TOTAL NO. USED	MFRS. CODE	GMC DWG. NO.
C1	Capacitor: fixed, ceramic, 100 pf, ±20%, 500 VDCW	1	71590	
C2	Capacitor: fixed, electrolytic, 1 mf, 150 VDCW	3	56289	
C3	Capacitor: fixed, paper .01 mf, ±10%, 200 VDCW	4	56289	
C4	Capacitor: fixed, electrolytic, 100 mf, 3 VDCW	2	56289	
C5	Capacitor: fixed, paper .047 mf, ±10%, 200 VDCW	2	56289	
C6	Capacitor: fixed, electrolytic, 40 mf, 250 VDCW	1	84171	
C7	Capacitor: fixed, ceramic, 1200 pf, ±20%, 500 VDCW	2	71590	
C8	Same as C2			
C9	Same as C3			
C10	Same as C4			
C11	Same as C5			
C11A	Capacitor: fixed, paper. Factory selected value used only for 50 cps operation.			
C12	Same as C3			
C13	Same as C2			
C14, C15	Capacitor: fixed, paper, .47 mf, ±10%, 200 VDCW	2	56289	
C16	Capacitor: fixed, mylar, 10 mf, ±10%, 200 VDCW	1	09134	
C17	Capacitor: fixed, ceramic, .05 mf, ±20%, 50 VDCW	1	71590	
C18	Same as C7			
C19	Capacitor: fixed, ceramic, .01 mf, GMV, 500 VDCW	3	56298	
C20, C21	Capacitor: fixed, electrolytic 50 mf, 3 VDCW	2	56289	
C22A, B	Capacitor: fixed, electrolytic, 50-30 mf, 350 VDCW	1	84171	
C23	Capacitor: fixed, paper, .1 mf, ±10%, 200 VDCW	1	56289	

TABLE III

REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION	TOTAL NO. USED	MFRS. CODE	GMC DWG. NO.
C24	Same as C3			
C25	Capacitor: fixed, electrolytic, 1000 mf, 25 VDCW	1	84171	
C26	Same as C19			
C27	This reference symbol not assigned			
C28	Capacitor: fixed, electrolytic, 100 mf, 15 VDCW	1	56289	
C29	Capacitor: fixed, ceramic, .02 mf, GMV, 500 VDCW	1	71590	
C30	Same as C19			
C31	Capacitor: fixed, electrolytic, 30 mf, 15 VDCW	1	56289	
CR1, CR2	Semiconductor Device, Diode: Type 1N3256	2	02735	
CR3, CR4, CR5, CR6	Semiconductor Device, Diode: Type 1N599	4	96214	
CR7	Semiconductor Device, Diode: Type 1N456	1	96214	
CR8	Semiconductor Device, Diode: Type 1N751A	1	96214	
CR9	Semiconductor Device, Diode: Type 1N746	1	96214	
DS1	Lamp, incandescent, Type 1465	1	72765	
DS2	Lamp, incandescent, Type 765	1	72765	
F1	Fuse: .5 amp, slow-blow for 115V operation, Type 3AG	1	75915	
	Fuse: .25 amp, slow-blow for 230V operation, Type 3AG	1	75915	
FL1	Filter, band pass	1	11332	2904C-1
G1	Chopper, electronic for 60 cps operation Chopper, electronic for 50 cps operation Chopper, electronic for 50-1000 cps operation	1	11332	2616F-1 2616F-2 3153C

TABLE III

REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION	TOTAL NO. USED	MFRS. CODE	GMC DWG. NO.
J1	Connector: receptacle, electrical	1	11332	2907A
J2	Jack: telephone, Type 11	1	82389	
M1	Ammeter	1	11332	1410D
Q1, Q4	Transistor: matched pair	1 Pr	11332	3011A
Q2, Q3, Q5	Transistor: Type 2N404	5	02735	
Q6	Transistor: Type 2N1304	1	02735	
Q7	Transistor: Type 2N2137	1	04713	
Q8, Q9	Same as Q2			
Q10	Transistor: Type 2N1991, used for 50-1000 cps operation only	1	04713	
R1	Resistor: fixed, film 1.037 megohm ±0.1%, 1/2 W	1	19701	
R2	Resistor: fixed, film, 479,700 ohms ±0.1%, 1/2 W	1	19701	
R3	Resistor: fixed, film, 151,300 ohms ±0.1%, 1/2 W	1	19701	
R4	Resistor: fixed, film, 47,830 ohms ±0.1%, 1/2 W	1	19701	
R5	Resistor: fixed, film, 15,120 ohms ±0.1%, 1/2 W	1	19701	
R6	Resistor: fixed, film, 4,774 ohms ±0.1%, 1/2 W	1	19701	
R7	Resistor: fixed, film, 1,503 ohms ±0.1%, 1/2 W	1	19701	
R8	Resistor: fixed, film, 468.4 ohms ±0.1%, 1/2 W	1	19701	
R9	Not used			
R10	Resistor: fixed, composition, 3,000 ohms ±5%, 1/2 W	4	75042	
R11	Resistor: fixed, composition, 2.2 megohms ±10%, 1/2 W	3	75042	
R12	Same as R10			

TABLE III

REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION	TOTAL NO. USED	MFRS. CODE	GMC DWG NO.
R13	Resistor: fixed, composition, 820,000 ohms ±5%, 1/2 W	2	75042	
R14	Resistor: fixed, composition, 200,000 ohms ±5%, 1/2 W	3	75042	
R15	Resistor: fixed, composition, 75,000 ohms ±5%, 1/2 W	2	75042	
R16	Resistor: fixed, composition, 30,000 ohms ±5%, 1/2 W	4	75042	
R17	Resistor: fixed, composition, 390,000 ohms ±5%, 1/2 W	4	75042	
R18	Not used			
R19	Same as R11			
R20	Resistor: fixed, film, 402,000 ohms ±1.0%, 1/2 W	1	19701	
R21	Resistor: fixed, composition, 22,000 ohms ±10%, 1/2 W	1	75042	
R22	Same as R17			
R23	Same as R10			
R24	Same as R11			
R25	Same as R10			
R26	Same as R13			
R27	Same as R14			
R28	Same as R15			
R29	Same as R16			
R30	Not used			
R31	Same as R17			
R32	Resistor: fixed, composition, 120,000 ohms ±10%, 1/2W for 60 cps operation 82,000 ohms ±10%, 1/2W for 50 cps operation 62,000 ohms ±10%, 1/2W for 50-1000 cps operation	1	75042	
R33	Same as R14	1	75042	
R34	Resistor: fixed, composition 3,900 ohms ±5%, 1/2 W	1	75042	
R35	Resistor: fixed, composition, 39,000 ohms ±5%, 1/2W	1	75042	

TABLE III

REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION	TOTAL NO. USED	MFRS. CODE	GMC DWG NO.
R36	Resistor: fixed, composition, 20,000 ohms ±5%, 1/2 W	2	75042	
R37	Resistor: fixed, composition, 1 megohm ±10%, 1/2 W	1	75042	
R38	Resistor: fixed, composition, 820 ohms ±5%, 1/2 W	1	75042	
R39	Resistor: fixed, composition, 13,000 ohms ±5%, 1/2 W	1	75042	
R40, R41	Same as R16			
R42	Resistor: fixed, composition, 82,000 ohms ±5%, 1/2 W	1	75042	
R43	Resistor: fixed, film, 56,200 ohms ±1.0%, 1/2 W	2	19701	
R44	Resistor: fixed, film, 1 megohm ±1.0%, 1/2 W	2	19701	
R45	Resistor: fixed, film, 196,000 ohms ±1.0%, 1/2 W	1	19701	
R46	Same as R36			
R47	Resistor: fixed, film, 49,900 ohms ±1.0%, 1/2 W	1	19701	
R48	Same as R44			
R49	Same as R43			
R50	Not used			
R51	Resistor: fixed, film, 110,000 ohms ±1.0%, 1/2 W	1	19701	
R52	Resistor: fixed, film, 976,000 ohms ±1.0%, 1/2 W	1	19701	
R53	Resistor: fixed, composition, 68,000 ohms ±5%, 1 W	2	75042	
R54	Resistor: fixed, composition, 2,200 ohms ±5%, 1/2 W	1	75042	
R55	Resistor: fixed, composition, 100 ohms ±10%, 1/2 W	1	75042	
R56	Resistor: fixed, wire-wound, 10 ohms ±0.1%	1	11332	2643E

TABLE III

REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION	TOTAL NO. USED	MFRS. CODE	GMC DWG. NO.
R57	Resistor: fixed composition 3300 ohms ±10%, 1/2 W	1	75042	
R58	Resistor: variable, wire-wound, 10,000 ohms	1	11332	2501D-2
R59	Resistor: fixed, wire-wound, 27 ohms ±5%, 1/2 W	1	75042	
R60	Resistor: variable, wire-wound, 25 ohms	1	11332	2501D-4
R61	Resistor: fixed, composition, 560,000 ohms, ±5%, 1/2 W	1	75042	
R62	Resistor: variable, wire-wound, 25,000 ohms	1	11332	3982A
R63	Resistor: fixed, composition, 470,000 ohms ±10%, 1/2 W	2	75042	
R64, R65	Resistor: fixed, composition, 510 ohms ±5%, 1/2 W	2	75042	
R66	Same as R17			
R67	Resistor: fixed, composition, 18,000 ohms ±5%, 1/2 W	1	75042	
R68	Resistor: fixed, composition, 1.5 megohms ±5%, 1/2 W	1	75042	
R69	Resistor: fixed, film, 93,100 ohms ±1.0%, 1/2 W	1	19701	
R70	Resistor: fixed, film, 71,500 ohms ±1.0%, 1/2 W	1	19701	
R71	Resistor: fixed, film, 121,000 ohms ±1.0%, 1/2 W	1	19701	
R72	Same as R53			
R73	Resistor: fixed, composition, 560,000 ohms ±10%, 1/2 W	1	75042	
R74	Same as R63			
R75	Resistor: fixed, composition, 2,000 ohms ±5%, 1/2 W	1	75042	
R76	Resistor: fixed, composition, 620 ohms ±5%, 1/2 W	1	75042	
R77	Resistor: fixed, composition, 100 ohms ±5%, 1/2 W	1	75042	
R78	Resistor: fixed, composition, 390 ohms ±5%, 1/2 W	1	75042	

TABLE III

REPLACEABLE PARTS

CIRCUIT REF.	DESCRIPTION	TOTAL NO. USED	MFRS. CODE	GMC DWG. NO.
R79	Resistor: fixed, wire-wound, 4 ohms ±5%, 10 W	1	75042	
R80	Not used			
R81	Resistor: fixed, film, 490 ohms ±1.0%, 1/2 W	1	19701	
R82	Resistor: fixed, film, 510 ohms ±1.0%, 1/2 W	1	19701	
S1	Switch, rotary, 8 positions	1	11332	2855B
S2	Switch, rotary, 3 positions	1	11332	2905C
S3	Switch, toggle, P/N 110B-73	1	73559	
T1	Transformer, audio	1	11332	2612D
T2	Transformer, power	1	11332	2856D
V1	Tube, electron: Type 7025	1	94154	
V2	Tube, electron: Type 12AX7A	2	94154	
V3	Tube, electron, Type 12AT7	1	94154	
V4	Tube, electron, Type 12B4A	1	94154	
V5	Same as V2			
V6	Tube, electron, Type 5651	1	94154	

*Part number for replacement chopper, G1, is dependent on the line frequency requirement of your unit. This information is marked on the rear chassis apron.

TABLE IV

LIST OF MANUFACTURERS CODES

Code	Manufacturer	Address
02735	RCA, Semiconductor and Materials Div.,	Somerville, N.J.
04713	Motorola Inc., Semiconductor Prods. Div.,	Phoenix, Ariz.
09134	Texas Capacitor Co., Div. K-C-K Corp.,	Houston, Texas
11332	General Microwave Corp.,	Farmingdale, N.Y.
19701	Electra Mfg. Co.,	Kansas City, Mo.
56289	Sprague Electric Co.,	North Adams, Mass.
71590	Centralab Div., Globe-Union Inc.,	Milwaukee, Wisc.
72765	Drake Mfg. Co.,	Chicago, Ill.
73559	Carling Electric Co.,	Hartford, Conn.
75042	International Resistance Co.,	Philadelphia, Pa.
75915	Littelfuse, Inc.,	Des Plaines, Ill.
77764	Resistance Products Corp.,	Harrisburg, Pa.
82389	Switchcraft, Inc.,	Chicago, Ill.
89171	Arco Electronics, Inc.,	New York, N.Y.
94154	Tung-Sol Electric, Inc.,	Newark, N.J.
96214	Texas Instruments, Inc., Semiconductor Components Div.	Dallas, Texas

EQUIPMENT WARRANTY

General Microwave Corporation warranties all parts of equipment of its manufacture to be free from defects caused by faulty material or poor workmanship. This warranty excludes electronic tubes, batteries, natural rubber and material normally consumed in operation unless such excepted items fail as a result of improper application by General Microwave.

Liability under this warranty is limited to the obligation to repair, or, at General Microwave's sole option, to replace without charge, FOB General Microwave's Plant, any part found to be defective under normal use and service within the time periods shown below, provided:

(1) General Microwave Corporation is promptly notified within the warranty period in writing upon discovery of such defects;

(2) The original parts or equipment are returned to General Microwave Corporation, transportation charges prepaid;

(3) General Microwave Corporation's examination shall disclose to its satisfaction that such defects have not been caused by abuse after delivery; and

(4) Warranties shall not apply to items which have been repaired or altered by others than General Microwave Corporation or its authorized agency.

The period of warranty is one year after delivery of the instrument to the original purchaser.

The warranty period shall not include any period of time the unit or part fails to perform satisfactorily due to such defect, and any unit, part or component repaired or replaced by General Microwave pursuant to this warranty shall itself be guaranteed as specified above.

PRELIMINARY INSTRUCTION SHEET

MODEL N420, N421 AND N422 COAXIAL
tft POWER HEADS

DESCRIPTION

Model Nos. N420, N421 and N422 denote three coaxial tft (thin-film thermoelectric) Power Heads designed for the measurement of radio frequency power over an extremely wide range of power and frequency. These units are intended for use with the GMC Model 454A Thermoelectric Power Meter and will measure amplitude and frequency modulated as well as CW signals. The power range of the tft Power Heads when used with the Model 454A extends from 0.3 microwatts full scale on the most sensitive range to 100 milliwatts full scale on the highest power range. Still higher powers can be measured using suitably calibrated couplers or attenuators. Frequency coverage extends from 2 mc to 12.4Gc in each of the three coaxial mounts.

The tft Power Heads incorporate a thin-film metallic load which, acting as well-matched termination, absorbs the incident r-f power. The load consists of bismuth and antimony sections which are vacuum deposited on a thin Mylar or mica substrate in a geometric configuration that produces a number of thermoelectric junctions. Some of the junctions are thermally "sinked" to the transmission line, while the remaining junctions are located in the air space between the lines. The absorbed r-f power increases the temperature of those junctions relative to the "sinked" junctions and thus a thermoelectric emf is generated proportional to the temperature rise and, therefore, to the absorbed power. By keeping the temperature differential between the junctions small, the unit acts as a true square law (rms) device producing a d-c output voltage directly proportional to the absorbed power.

Although this attribute permits a tft Power Head to be used with any d-c voltmeter that has adequate sensitivity and accuracy, the most convenient indicator to use is the GMC Model 454A which is equipped with the following special features:

1. Direct reading in power rather than voltage. No conversion required.
2. Automatic adjustment for each tft Power Head sensitivity factor.
3. Interlock circuitry to indicate when incorrect scale ranges are employed.
4. Temperature compensation circuits to correct for sensitivity factor temperature coefficient.
5. Shielded low noise connector.

OPERATION

To place the tft Power Head into use, it should be first connected to the Model 454A and the instrument zeroed to balance out any residual thermal emf's. (The detailed operating procedures for the Model 454A are given in the Operation and Service Manual supplied with that instrument.) The tft Power Head is then connected to the r-f system under test and the r-f power will be indicated on the Model 454A.

Although the tft Power Heads are rugged, dependable units that will give reliable, trouble-free service when operated within their ratings, they are subjected to burnout when overloaded. Table I lists the power ratings for the three series.

TABLE I - Power Ratings for tft Power Heads

Model	Avge. Power, Continuous Duty	Max. Peak Power*
N420	10 mw	10 W
N421	100 mw	30 W
N422	1 mw	0.3 W

While the tft Power Heads will take overloads of up to 300% for short periods of time, extended periods of operation at this level or exceeding these ratings may result in permanent change in the tft element characteristics or even burnout. Maximum care should be exercised to avoid this occurrence.

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* Tentative ratings for PRF's greater than 50 cps. At lower frequencies, this should be reduced.

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